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Effect of Mutual Coupling on Microstrip Antenna

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Abstract

The purpose of this study is to observe the effect of mutual coupling on microstrip antenna (MSAs). A modification is done in such a way that, a gap coupling is used to increase the separation between the frequency bands. Before this phenomenon was introduced, there were problems such as destructive interference caused by the multiple resonant frequencies which implies the mutual coupling effect. In multi-resonant configurations, separation between the resonant frequencies is varied to make them operate in desired frequency band. The separation between the resonant frequencies of individual elements, is sufficiently increased and by appropriately providing the matching for different resonances, dual or multi frequency operation is obtained. Also, a brief summary of radiation characteristics of these microstrip antennas is presented, which can help in deciding whether these structures are suitable for their use in various applications with particular requirement for radiation pattern.A model is designed to resonate at 750MHz and 1.16GHz, which gives two resonant frequencies.

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*Keywords:*Mutual coupling on microstrip antenn(MSAs); resonant frequency; multi-resonant configuration; radiation pattern.

1. Introduction

In high performance aircraft, spacecraft, satellite, and missile applications, where size, weight, cost, performance, ease of installation, low-profile antenna may be required. A metallic strip consist of patch or a strip of conducting material placed on a substrate layer that is dielectric, supported by a ground plane. It is formed from a very thin metal patch fraction of a wavelength above a ground plane, ideally a material with an infinite conductivity. The patch is etched on a dielectric substrate, which separates the patch and the ground plane. This dielectric typically has a dielectric constant of $2.2 \le \varepsilon_r \le 12$, although foam substrate have been developed which can have a dielectric close to that of air ($\varepsilon_r = 1$). In general, for antenna applications it is favorable to use a thick, low dielectric constant substrate. This results in loosely bound fields so that there is greater radiation, and a higher bandwidth and efficiency. However, the patch size will be increased, and with the increase in height, there will be an increase in

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surface waves. The low mutual coupling and good matching characteristics can be achieved by optimizing the dimensions of the patches [3]. These type of antennas are simple, light and inexpensive. Due to the flexibility with which they can be constructed, they can be designed for a variety of different resonant frequencies. Impedances, and radiation patterns. The property of antenna are altered by modifying the geometry and feeding method. It is observed that with increase in the number of parasitic resonators, the enhancement in the bandwidth of the individual frequency band is up to configuration of eight resonators. After that the frequency ratio increases but the bandwidth reduces for dual frequency operation. Similarly for tri-band, it is observed that the separation between the individual band increases with increase in the number of resonators but increase in the bandwidth of the individual frequency band is insignificant. All these configurations are obtained by splitting a RMSA, and the resonating lengths were changed together with the gap widths. Further multiple frequency resonances may be obtained beyond the six resonating configuration by optimizing the resonating lengths of the parasitic resonators and the gap widths between them [1]. This paper deals with two resonators that are formed by splitting a single rectangular microstrip antenna along the width where optimizing the gap coupling and resonating lengths of resonators yields dual and tri-band frequency operation. Of these smaller resonators, both the resonators are co-axially fed while the effect of gap coupling is observed [7, 8]. The design of a microstrip patch antenna with different shapes to create multi-band has been achieved by using different shaped-slots [9, 10].

1.1 Constructional Details

Microstrip Antenna (MSA), in simple terms, can be described as consisting of a radiating patch on top of a dielectric substrate, bounded by ground plane at the bottom. Radiation from the MSA is primarily due to fringing fields between the periphery of the patch and the ground plane as shown in the Fig 1(a) below. The substrate parameters such as height, dielectric constant etc. are appropriately chosen, so as to enhance the fringing fields to maximize radiation.

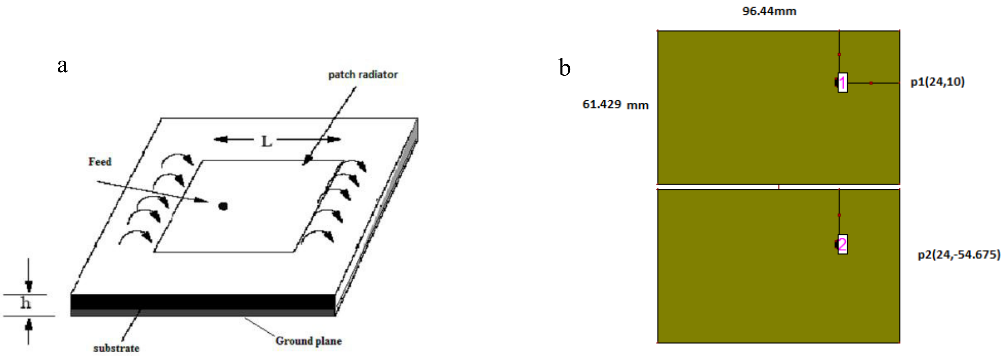

Fig 1. (a)A rectangular shaped microstrip antenna, (b) Strips with two feed points.

MSAs have found wide ranging applications in the field of mobile, satellite communications, defence and numerous other areas primarily due to several attractive features that these structures possess, such as:

- Low weight
- Low profile
- Conformity to host surface

However, major disadvantage of MSAs is their inherent narrow bandwidth, which can be a severe impediment to their use in various applications. This problem of increasing the bandwidth of MSAs has received considerable attention over the years and numerous techniques have been devised to tackle this problem. The various configurations used as a feed for MSA's are divided as: - Line feed, Co-axial probe feed, Aperture coupled

feed, Proximity feed. Out of this co-axial line feed is used. Co-axial feed, where the inner conductor of coax is attached to the radiation patch while the outer conductor is connected to the ground plane.
Significance of Co-axial line feed are: -

- Easy to fabricate and match
- Low spurious radiation(-30dB)
- Narrow Bandwidth (1-3%)

2. System Model

The input impedance is specified in terms of VSWR or return loss. Usually VSWR ≤ 2 or return loss ≥ 10 dB is taken as the limit. It has been noted that, bandwidth for a given limiting value of VSWR is inversely proportional to the unloaded quality factor of the antenna. To obtain two resonant radiating structure both the patches are fed. In this case if there are parasitic elements, two categories can be defined depending on how the parasitic are coupled to the fed element. The parasitic can be on the same layer as the fed element i.e. planar multi resonators or on the different layers i.e. multilayer or stacked configurations. In gap coupled RMSAs, the coupling between the fed and parasitic patches is by means of gap between them. The gap has capacitive effect and this capacitance depends on the width of the gap. This gap width and feed point location have to be modifiedto obtain proper matching. The gap width is kept large enough so that coupling due to gap capacitance is minimized. In this project the coupling is done using SMA connectors and fed to the two strips. As the additional resonators are obtained from the original patch itself, by dividing it into smaller elements, the size of the overall configuration is more or less same as that of the single, conventionally designed MSA. Also, as the same principles for broadband operation, are also applicable for multi frequency operation with slight variation, these gap coupled configurations are also studied for their suitability for dual and multi frequency operations.

2.1. System Specifications and Design

These antennas are conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed circuit technology, mechanically robust when mounted on rigid surfaces. When the particular patch shape and mode are selected, they are very versatile in terms of resonant frequency, polarisation, pattern and impedance. The length and width needed to design this MSA is given as,

$$\mathbf{L} = \frac{\mathrm{Co}}{2\mathrm{Fr}\sqrt{\in\mathrm{r}}} \tag{1}$$

$$\mathbf{W} = \frac{\mathrm{Co}}{2\mathrm{Fr}\sqrt{(\in\mathrm{r}+1)/2}} \tag{2}$$

For test purpose we considered Fr = 750 MHz,$\in$r = 4.3, Co = 3X10^8m/s and obtained the length and width of the patch
L = (3 x 10^8)/2 x 750 x 10^6 x$\sqrt{4.3}$, **L** = 96.448 mm….as per equation (1)
Similarly, W = (3 x 10^8)/2 x 750 x 10^6 x$\sqrt{(4.3+1)}$/2, W = (3 x 10^8)/2 x 750 x 10^6 x$\sqrt{5}.3/2$
W = 122.859 mm….as per equation (2)

Assuming feed point location at P1 (24mm, -54.67mm) and P2 (24mm, 10mm). Feed point is located at the best place where faithful results are obtained. Simulation software was used called IE3d a Zealand product and the desired results were obtained. This software was used to design the antenna and therein simulate to observe the results. Depending upon the results complete study related to its performance in presence of applied signal was verified and complimented for the its best suited area of application.

a b

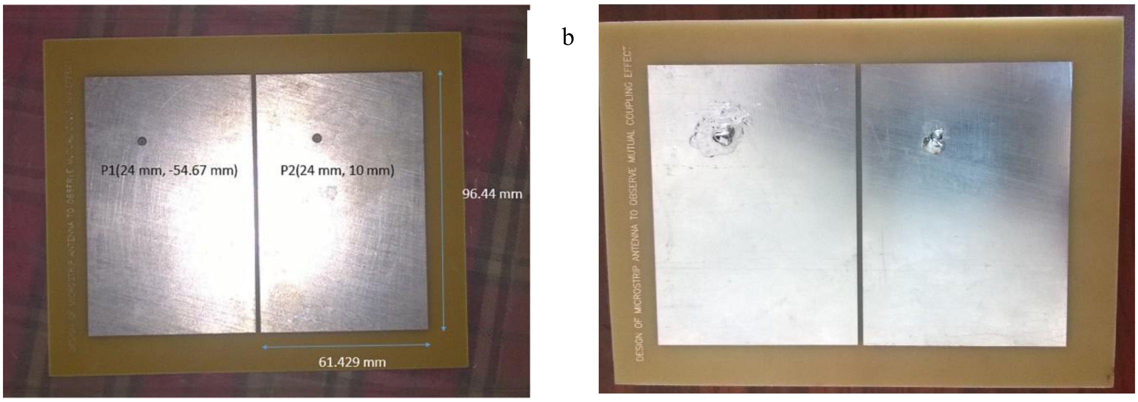

Fig 2. Rectangular MSAs Patch with (a) feed locations, (b) co-axial feeds.

Thereafter a hardware is implemented on double sided PCB board. Out of which one side acts as an infinite ground surface and the other side we have the layout impression of intrested area. The holes are drilled at specified location and using SMA connectors they are fed.

3. Simulations and Results

Consider the frequency range to be 0.5GHz-3GHz with meshing frequency to be 3GHz in the software. The VSWR graph, radiation pattern, S11 parameter graph and directivity is traced out by the software as shown in the figures below.

a

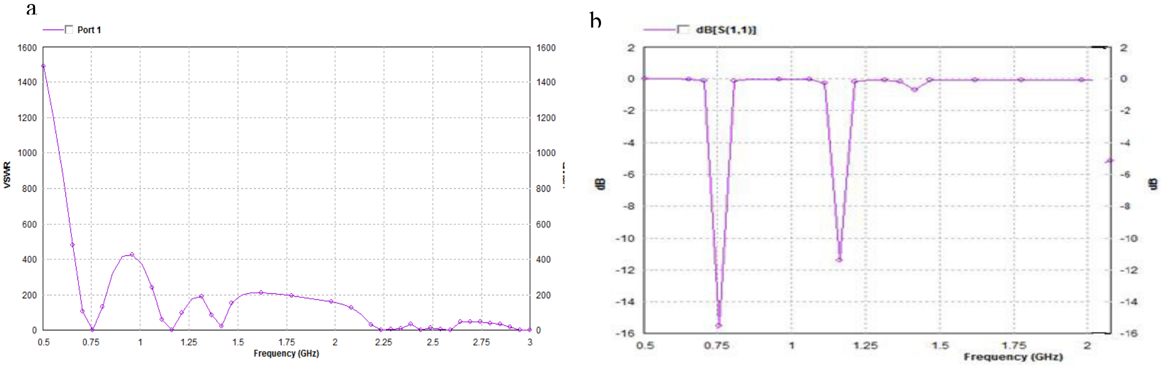

Fig 3. (a) Variation of VSWR verses Frequency, (b) S11 Parameter at microwave frequency.

Fig 3(a). Shows the resonant frequency cut off with at frequency axis as F1=750MHz and F2=1.16GHz. Also the S parameter graph of Fig 3(b). Shows operation of antenna at microwave frequencies with maintaining the value of VSWR. Thus the effect of co-axially coupled feed point to the strips is studied.

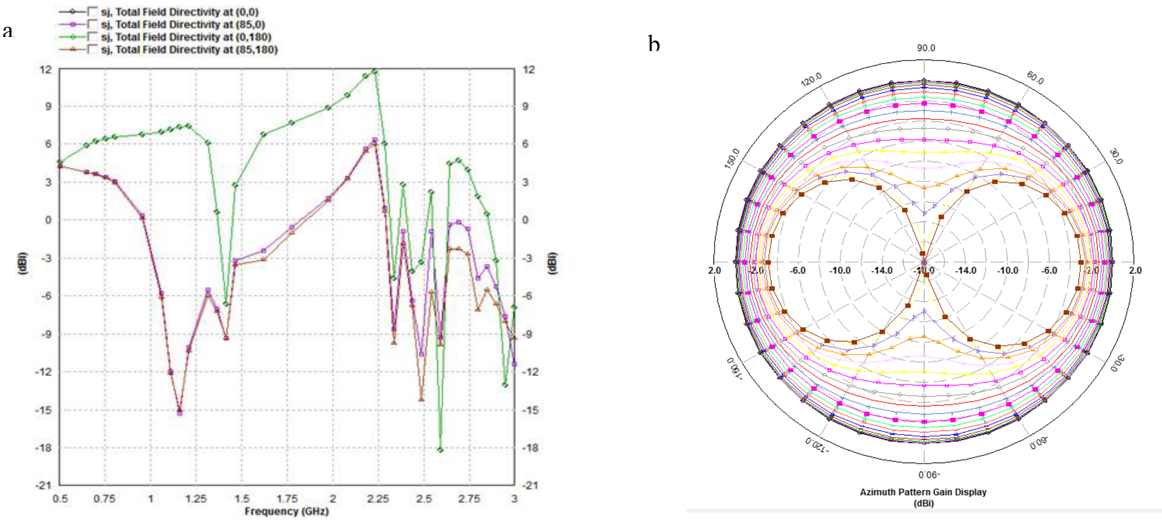

Fig 4. (a) Directivity verses Frequency, (b) Radiation pattern.

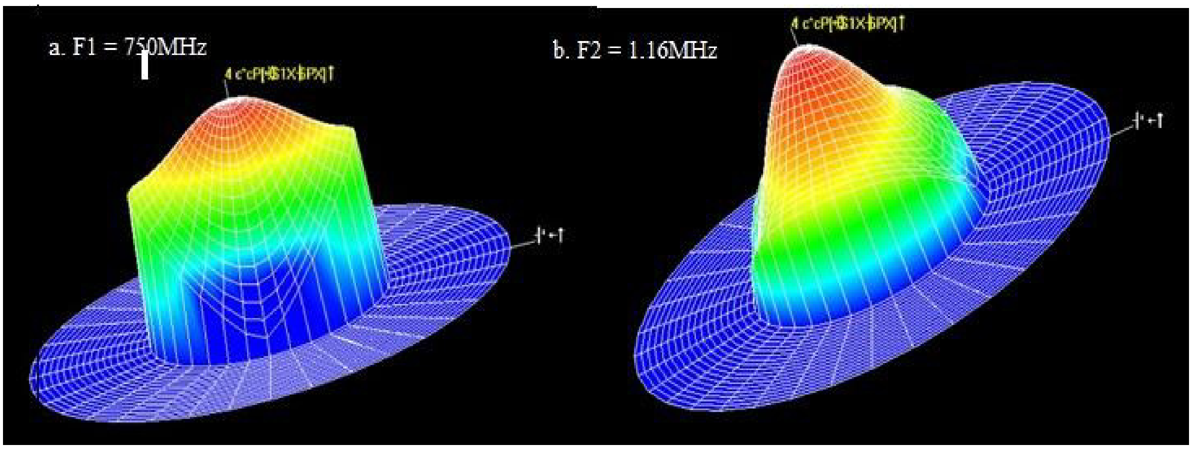

Fig 5. Radiation pattern in 3D (a) F1=750MHz, (b) F2=1.16GHz.

4. Conclusion and Future Scope

Rectangular configuration of microstrip antenna is most commonly used. Thus by obtaining dual or multi band resonating frequencies VSWR in the required range 1≤ VSWR≤ 2, Return loss (RL<-10dB) is obtained. The directivity and radiation pattern observed is also considerable. Thus the disadvantage of microstrip antenna that is narrow bandwidth is removed to certain extent, which is made possible by decreasing the mutual coupling effect. This antenna is used as a transceiver and in future for mobile phones with two SIM cards which make them more bulky and complex. But this technique will replace any number of operators in single setup making the system compact, simpler, and thus will be a revolutionary method.On a telephone tower there are different antennas for different operators like BSNL, IDEA etc. there using this technique it is possible to implement the complete complex structure in a single setup.

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